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A STUDY OF *APHIS SAMBUCI* L. (HEMIPTERA: APHIDIDAE) AND A DISCUSSION OF ITS BEARING UPON THE STUDY OF THE "BLACK APHIDS."

PART II.

F. H. JACOB.

(*Ministry of Agriculture and Fisheries, National Agricultural Advisory Service, Bryn Adda, Bangor.*)

BIOLOGY.[1]

During four seasons only a single egg was found, so that little is known about oviposition under natural conditions. In culture, however, a fairly large number of eggs was laid, and where the plants were of suitable size and the cages not overcrowded, they were laid in the axils of buds and in cracks of the bark, the latter site appearing to be preferred. The single egg already referred to was well concealed in the bark, and it seems probable that this may be one reason for the failure to find eggs in nature. In culture in an unheated and well-ventilated glasshouse, hatching commenced in mid-March, and the fundatrices matured in two to three weeks. The progeny of the fundatrices were entirely apterous and the adults characterised by transverse wax bands on the abdomen; they matured in from seven to ten days, but, however, development proceeds much more slowly in nature. The aphids feed on the young green stems and petioles. Al. v. females appear in the third and subsequent generations, no generation having been observed to consist entirely of alatae, with the result that colonies have been found on *Sambucus nigra* throughout the summer. In nature alatae begin to appear from mid-May to early June; they show a marked tendency to congregate on the leaves, a tendency which is also shown to some extent by the last nymphal instar; some of them migrate to secondary host plants and possibly to other *S. nigra*, the writer having found colonies on the subterranean parts of the following plants: *S. angustifolia*, *Lychnis alba* Mill., *L. dioica* L., *Dianthus* sp., *Saxifraga* sp., and *Rumex* sp. (probably *R. obtusifolius* L.); and Dr. D. Hille Ris Lambers has informed the writer that he has found *A. sambuci* on the roots of the following: *Bursa pastoris* Weber, *Cerastium arvense* L., *Dianthus plumiarius* L., *D. arenarius* L., *D. asper* Wildemow, *D. barbatus* L., *Spergula arvensis* L., *R. crispus* and *R. obtusifolius*. Patch (1938) lists a number of additional host plants which have not been verified.

The subterranean colonies are almost invariably attended by ants, as are the aerial colonies on *S. nigra*, and it seems to be very likely that the establishment of the former is facilitated by their activities; this is suggested by the fact that in the absence of ants, it is very difficult to establish colonies on many of the above hosts and that when established they are never subterranean; this probably also explains the transference results of Mordwilko (1907) and Börner (1931). The following species of ants are commonly concerned: *Myrmica ruginodis* Nylander, *M. laevinodis* Nylander, *Lasius niger* (L.), *L. flavus* (F.), and the only colony of *L. fuliginosus* (Latreille) known to the writer is thought to have maintained a colony of *A. sambuci* on the same plant of *S. nigra* for at least three years.

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[1] For Part I see page 90.

From about mid-July onwards a number of alatae remain on *S. nigra* and produce characteristic colonies of yellow ovip. ♀. At Newcastle-on-Tyne and in south Durham in late July and early August, 1943, several bushes were almost completely smothered and defoliated by such colonies, but only a single male was found on them; as similar early production of gynoparae and absence of males has been noted at other places in other years, it would appear that this habit has little survival value. It is only in cultures that an appreciable number of males has been found on *S. nigra*; at no time were appreciable numbers found on wild *S. nigra*. The only natural situation in which they have been at all plentiful is on the roots of the summer hosts. Gynoparae and males return to *S. nigra* from August to November; it has not been possible to prove whether they are the progeny of the same parents, but they do appear on their host plants at the same time and in approximately equal numbers and are presumably of the same generation. This helps to explain the relatively small proportion of males to ovip. ♀, as each gynopara produces 10–12 ovip. ♀ the sex ratio is theoretically about 10–12 : 1, but such a high proportion of males has never been found. Successful fertilization presupposes the arrival of males when there are mature ovip. ♀ available, which is provided for by the long period during which these forms are found. Börner (1931) stated that males and ovip. ♀ are the progeny of the return migrants; this does not appear to be correct. Oviposition can occur in culture throughout the period August to November. Simultaneously, colonies remain on the secondary host plants where they can be found throughout a mild winter.

It has been observed frequently in the field and carefully confirmed in culture that the gynoparae occasionally give rise to apt. v. ♀, not more than one or two per gynopara, and they seem to be the last born, so that small groups of yellow larval ovip. ♀ occasionally contain a single green larval apt. v. ♀. These apt. v. ♀ are capable of normal reproduction and many produce a further generation of gynoparae; they also produce apt. v. ♀ which give rise to overwintering colonies; in the event of the failure of the sexual forms this is undoubtedly a character of considerable survival value.

During the winter subterranean colonies, attended and possibly maintained by ants, can be found on *S. nigra*, and during mild weather, when *S. nigra* tends to grow, it is possible to find small numbers of apt. v. ♀ and larvae on the shoots. In the spring these overwintering colonies move up on the rapidly-growing basal shoots which may bear colonies a foot or more in length. It has been suggested above that colonies derived from eggs are characterized by the wax adornment of the apt. v. ♀, whereas colonies derived from overwintering apt. v. ♀ are without such wax; additional evidence is derived from their relative situations on the plant. The former have been most frequently found on the extension growth of old branches, and the latter on the basal shoots which grow from soil level or below it.

EXPERIMENTAL WORK.

During the winter of 1944–45 and from the spring of 1945 until the spring of 1946 a number of experiments were carried out in order to investigate the identity of *A. sambuci*-like aphids found on various other host plants, and the opinions formed about the synonymy of these aphids. This work revealed a number of interesting biological and morphological features of *A. sambuci*, in addition to problems involved in the attempt to transfer aphids from one host to another, which will be discussed below.

The plants used in all experiments were grown in earthenware flower pots of a size suitable to each particular plant; the plants were covered with hurricane lamp glasses closed at the top with butter muslin, or with butter muslin sleeves supported on wire frames. As far as possible, plants were not used until they had become well established. Most of the pots were kept in a well-ventilated unheated glasshouse; others were left out of doors on a flat roof.

The experiments carried out were of two kinds—

(A) Simple transference from one host to another.

(B) Attempts to cross males and oviparous females derived from different hosts. Experiments under (A) were divided into three classes:

I. Transference to *S. nigra* from all hosts upon which *A. sambuci* was found.

II. Transference from *S. nigra* to known or suspected alternative hosts.

III. A combination of I and II involving the use of aphids successfully transferred to *S. nigra* in an attempt to colonize known or suspected alternative hosts. This was planned as a control, and as a measure of the efficiency of the experiments.

Class (A)I.

Colonies of *A. sambuci* were obtained from *S. angustifolia*, *L. alba*, *L. dioica*, *Dianthus* sp., *Saxifraga* sp. and *Rumex* sp., and specimens from each plant successfully transferred to *S. nigra*. This was done mainly in the autumn when gynoparae produced typical clusters of ovip. ♀♀, and apt. v. ♀♀ gave rise to gynoparae; every attempt succeeded and, in addition, several males from these plants fertilized ovip. ♀♀. In this way it was shown that aphids on *Dianthus* and *Saxifraga* spp. which agreed with the description of *A. wilsoni* could readily be transferred to *S. nigra* where they behaved in exactly the same way as, and were indistinguishable from, *A. sambuci*.

Classes (A)II and (A)III.

The experiments in these classes are summarized in Table II. The hosts to which transference was attempted are shown along the top of the table, and the source of the aphids is shown down the left-hand side, each section is divided into successful attempts (S) and failures (F).

TABLE II.—*Results of Transferring Aphids from Several Cultures of* A. sambuci *to a Number of Host Plants.*

From	To *S. angustifolia*	 *L. alba*	 *L. dioica*	 *R. obtusifolius*	 *R. crispus*	 *R. acetosella*	 *R. acetosa*
S.N.C. .	2S, 2F	1S, 3F	0S, 2F	5S, 0F	2S, 2F	0S, 3F	0S, 4F
S.N.R. .	.	2S, 4F	0S, 3F	1S, 0F	2S, 0F	.	0S, 1F
L.A. . .	1S, 2F	5S, 0F	4S, 0F	.	.	.	.
S.A./S.N. .	.	0S, 2F	0S, 2F	.	.	.	.
L.A./S.N. .	.	4S, 0F	2S, 0F	8S, 0F	2S, 0F	0S, 2F	0S, 1F
L.A./R.O. .	.	3S, 1F	.	.	.	.	.
S.N.R./R.C.	.	0S, 2F	.	.	.	.	.
S.N.C./R.O.	.	0S, 2F	.	.	.	.	.
S.N.C./R.C.	.	0S, 2F	.	.	.	.	.

KEY TO SOURCE OF APHIDS.

S.N.C. . .	A clone derived from *S. nigra.*
S.N.R. .	A colony derived from roots of *S. nigra.*
L.A. . .	,, ,, ,, *L. alba.*
S.A./S.N. .	,, ,, ,, *S. angustifolia* but reared on *S. nigra* (a clone).
L.A./S.N. .	A colony derived from roots of *L. alba* but reared on *S. nigra.*
L.A./R.O. .	L.A. Bred on *R. obtusifolius.*
S.N.R./R.C. .	S.N.R. ,, *R. crispus.*
S.N.C./R.O. .	S.N.C. ,, *R. obtusifolius.*
S.N.C./R.C. .	S.N.C. ,, *R. crispus.*

(The results shown in Table III are not included in Table II).

In these attempts apt. v. ♀♀, al. v. ♀♀, 3rd and 4th instar larvae were used, depending on the supplies available. The measure of success was arbitrarily chosen as the establishment of a thriving colony; in this way the failures include cases where aphids lived for several months without establishing such colonies, e.g. one transfer of clonal aphids from *S. nigra* to *R. crispus* in which the aphids reproduced a few larvae which lived for two months before dying; this occurred also in the case of the same stock transferred to *L. dioica*. Al. v. ♀♀ have to be used with care, during the autumn and early winter months they consist of gynoparae only; where they failed to reproduce on a summer host plant they were removed to *S. nigra* where, if not exhausted, they gave birth to ovip. ♀♀; from about December onwards al. v. ♀♀ gave rise to apt. v. ♀♀. However, the behaviour of gynoparae is not perfectly stable; for, as mentioned already, it was frequently noted that after producing a number of ovip. ♀♀ a gynopara would give birth to one or sometimes two apt. v. ♀♀; this was proved by careful observation of isolated specimens, and in fact, the two clones used in this set of experiments were produced in this way.

With the exception of *R. acetosella* and *R. acetosa* all the plants used were known host plants, so that if these are disregarded, the results of the remaining transfers give an indication of the limitations of this type of experiment. The work was carried out under uniform but unnatural conditions, and as a result it was only in the case of *S. nigra* that normal colonies were produced, and only in exceptional cases that aphids went on to the subterranean parts of the plant; actually in two cases where large aerial colonies were present and the soil was loose ; however, the aphids did show a tendency to favour the basal parts of the plants. The explanation of these failures is almost certainly that in nature *A. sambuci* is attended by ants which heap soil over the basal colonies and encourage the subterranean habit. After these experiments had been carried out, Dr. D. Hille Ris Lambers suggested that the results might well have been very different if they had been carried out in the presence of suitable species of ants ; it is the writer's opinion that this is undoubtedly correct. There is, however, another factor which seems to involve adaptation to food supply. It was thought that transferred aphids might have some difficulty in adapting themselves to a new food-plant ; to test this a further experiment was carried out using *L. alba* as the food-plant and aphids from four sources, namely, *L. alba* as a control, *L. alba* but bred on *S. nigra* for several generations, a clone from *S. nigra* and the progeny of a colony found on the roots of *S. nigra*. Four plants of *L. alba* were used in each treatment and three adult apt. v. ♀♀ were placed on each plant, except in two cases where sufficient apt. v. ♀♀ were not available and al. v. ♀♀ had to be used ; in each case they bred successfully. The number of aphids on each plant was counted at intervals of a few days, and the results are shown in Table 3.

TABLE III.—*The Number of Offspring Produced on* L. alba *by Samples of* A. sambuci *Derived from Four Different Sources.*

Source of aphids	Number of days						Remarks
	2	4	6	10	17	22	
L.A.	7	29	61	130	320	α	Successful transfer to all plants.
L.A./S.N.	2*	3	4	24	28	α	,, ,,
S.N.C.	.	5	7	8	10	5	Successful transfer to two plants.
S.N.R.	.	4	8	8	2	2	Successful transfer to one plant.

For key, see Table II.

* In this series apt. v. ♀♀ were placed on 2 plants and al. v. ♀♀ on 2 plants.

The control series indicate the normal rate of reproduction: adults developed in 17 days and by the 22nd day the aphids were too numerous to count. The same strain of aphids conditioned by feeding on *S. nigra* bred much more slowly, but when adults appeared, the rate of reproduction was comparable to the controls. In the case of the *S. nigra* strains, reproduction was very slow and, owing to the writer's change of station, it was not possible to continue the experiment. However, it is believed that when these aphids became mature they would have behaved normally. If, as seems reasonable, failures can be explained in this way, i.e. absence of ants and food conditioning, then it can be said that the above experiments are sufficient to prove the identity of the aphids found on the roots of *S. angustifolia* and *L. alba*. *Rumex* spp. were included in order to investigate Börner's (1931) statement that *A. sambuci* can be transferred to the leaves of *R. crispus* and *R. obtusifolius*.

In addition to the above experiments numerous unsuccessful attempts were made to establish *A. sambuci* on *Dianthus* and *Saxifraga* spp. on which it is known to feed.

Class B.

During 1943 and 1944, in spite of intensive searching, only two males of *A. sambuci* were found, and therefore in May, 1945, a number of clonal cultures were started in the hope that males would develop; such cultures were reared from aphids which had arisen from subterranean winter colonies on *S. nigra*, from what were suspected to be the progeny of fundatrices, and also from the roots of *Rumex* sp. A moderate number of males was produced in the cultures thought to be derived from fundatrices and very few in the others; however, conditions were not such as to rule out the strong possibility that this difference was accidental.

During the summer and early autumn, colonies of *A. sambuci* were found on *L. dioica*, *Dianthus* sp. and *Saxifraga* sp. In the autumn, males were plentiful on these plants, and as a plentiful supply of potted *S. nigra* was available it was decided to carry out a series of attempts at cross-fertilization. The results of this experiment are grouped in Table IV.

Table IV.—*Results of Crossing* A. sambuci *Obtained from Different Sources.*

	♂♂						
♀♀	A.S.W.	A.S.1	A.S.2	A.S.3	L	D	S
A.S.W.	E	.	.	.	.	.	E, F
A.S.1	.	E, F	.	.	.	E, F	.
A.S.2	.	.	E	.	E	E, F	.
A.S.3	.	.	.	E	.	.	.
L	.	E, F	.	.	E, F	E, F	E
D	.	E, F	.	.	.	E, F	E, F
S	.	.	.	.	.	.	E

Key.

A.S.W.—Wild specimens of *A. sambuci*.
A.S.1, 2 and 3.—Clones of *A. sambuci*.
L.—Aphids derived from *L. dioica*.
D.— ,, ,, ,, *Dianthus* sp.
S.— ,, ,, ,, *Saxifraga* sp.
E.—Apparently normal eggs as a result of cross.
F.—Fundatrices hatched and later generations developed.

For the purposes of this experiment the production of normal shiny black eggs has been regarded as the criterion of success, and the development of fundatrices and later generations as confirmation. There are several reasons for this; when unfertilized eggs have been laid, it has been noticed that they do not turn black; secondly, many eggs were laid on the surfaces of the cages where they eventually collapsed; thirdly, in the case of the clones where large numbers of eggs were laid, the viability was very low; finally, the results obtained when using wild material collected at random suggest very strongly that in the laboratory there was some unknown factor which militated against successful hatching. The results of this experiment show quite clearly that the so-called *A. wilsoni* from *Dianthus* and *Saxifraga* will interbreed with *A. sambuci*.

The number of crosses was less than had been hoped for because the supply of males did not always coincide with the development of ovip. ♀♀ from each source. Some of the results of these experiments have been mentioned and will be referred to in discussing the morphological variation of *A. sambuci*.

These experiments have been described in some detail for two reasons: firstly because they were necessary to prove the synonymy and biology of *A. sambuci*, and secondly because the number of failures in transferring this aphid to known hosts indicates some of the disadvantages inherent in this type of experiment. It is suggested that negative results should be treated with great caution and that the observation of experimental cultures should be maintained for as long as possible.

Discussion.

It has been suggested that a study of *A. sambuci* might be of interest in relation to the study of the group of "Black Aphids" comprising the *A. fabae* complex, and in fact, certain features of possible significance have been found. In order to assess the value of such observations it is desirable to be sure of the relationship of *A. sambuci* to the "Black Aphids"; this is not an easy thing to do, but it is thought that their relationship is fairly close.

The systematic relationship is the subject of divergent opinion, Börner and Schilder (1932) place all the "Black Aphids" in the genus *Doralis* Leach, leaving *A. sambuci* and *A. clematidis* Koch as the only representatives of *Aphis* L.; however, this division is not universally accepted. Their separation is based upon larval chaetotaxy which at the time constituted a new taxonomic character to which these workers adhered rigidly, and, as has been suggested to the writer by Dr. D. Hille Ris Lambers, in this case their adherence to the character may have been too rigid. *A. sambuci* differs from the "Black Aphids" to such an extent that it cannot be confused with them; however, when examined closely the difference is found to be largely due to the sum total of a number of characters each of which may be reproduced in one or other of the species which Börner and Schilder placed in *Doralis*; e.g. in *A. sambuci* the shape of the cauda, the appearance of the marginal tubercles and the absence of abdominal pigmentation in apt. v. ♀♀ are highly characteristic, but caudae of somewhat similar shape, similar marginal tubercles and lack of pigmentation occur in species which were placed in *Doralis*, but they do not occur in combination. The work described above suggests that *A. sambuci* resembles *A. fabae* in its somewhat polyphagous habits. In addition, some of the biological differences and the tendency to morphological variation are exhibited by *Aphis* spp., and also in other genera; e.g. in Great Britain overwintering of parthenogenetic females occurs in *A. fabae* or its very close relations, and has been observed by the writer in at least one other species of *Aphis*. It is common in other genera, e.g. *Myzus persicae* Sulzer and *Brevicoryne brassicae* L., where it is probably the most important method of overwintering in areas with a mild climate; in *Myzus ornatus* Laing the sexual phase is unknown. As an example of extreme morphological variation there is the case of *A. urticaria* Kaltenbach and its summer form, *Pergandeida stanilandi* Theobald, where the differences are more marked than those existing between *A. sambuci* and *A. wilsoni*. It seems to the writer that it may eventually be possible to support Börner and Schilder, but that at the present time it is desirable not to accept their division, which allows it to be assumed that the relationship between *A. sambuci* and the black aphids is as between species of the same genus, so that there seem to be adequate grounds for attempting to apply the knowledge gained from the study of *A. sambuci* to the study of the "Black Aphids."

Jacob (1945) has summarized the history of the classification of the "Black Aphids," and has indicated how *A. fabae* has been split up into a number of other species. This splitting has sometimes depended upon what seem to be slight differences, or differences in only one or two characters of questionable value. As already mentioned, *A. sambuci* exhibits a wide morphological variation, and it is thought that an examination of certain of these variations may be of assistance to workers interested in the *A. fabae* problem.

The morphological variations existing between samples of *A. sambuci* from different host plants and at different seasons have been indicated, and there also seem to be geographical variations. When some of them are considered it will be seen that they are similar to differences often regarded as specific in other genera, e.g. on purely morphological characters *A. wilsoni* might stand as a distinct species; it differs from what has been referred to as typical *A. sambuci* in several characters which are frequently used in taxonomy, e.g.:

(1) The relative lengths of the following appendages:
  (*a*) Cauda and siphunculi.
  (*b*) Last segment of rostrum and 2nd joint of hind tarsus.
  (*c*) Longest hairs on antennal segment III and the basal diameter of the segment.
(2) The absence of wax adornment in apt. v. ♀♀.
(3) The presence of secondary rhinaria on antennal segments IV and V in the al. v. ♀♀.

It is only when the biology of *A. sambuci* is understood that it can be said that these variations are normal. It is proposed to discuss the above characters in some detail as it is the writer's opinion that it is of value to examine those characters which are employed by the taxonomist. It must be pointed out that the variation in apt. and al. v. ♀♀ is undoubtedly increased by the subterranean colonization of the secondary hosts; loss of pigment, reduction in size of appendages and hairs may all be regarded as characters induced by this mode of life.[2]

Relative Lengths of Cauda and Siphunculi.

Walker (1850) mentions a variation in the proportion of the siphunculi to the body length, and although feeding conditions have a marked effect on body size, there is a conspicuous variation in siphuncular length. The extremes of variation are as between the "typical" spring form of apt. v. ♀♀ and the *Saxifraga* root form; in the former the siphunculi are from about

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[2] Hille Ris Lambers (1939) in discussing myrmecophily in *Pharalis* Leach and related genera, points out that myrmecophilous genera commonly show a reduction in wax secretion and size and shape of siphunculi and cauda. It is possible that myrmecophily is responsible for the reduction shown by certain forms of *A. sambuci* where, although all stages are attended by ants, there are differences in the degree of their activities. There is, however, a great difference between the variation found within the one species, *A. sambuci*, and the fixed or inherited differences existing between *Dactynotus*-like genera.

$2\frac{1}{2}$–$3\frac{3}{4}$ times as long as the cauda, in the latter from about $1\frac{5}{6}$–$2\frac{3}{5}$ times. There is a whole series between and overlapping these ranges, and the shape of the siphunculi varies. By rearing the "typical" form under adverse conditions this character approximates to the proportions found in root forms. This has been shown in both clonal and mixed material.

Relative Lengths of Last Segment of Rostrum and Second Joint of Hind Tarsus.

Throughout the material measured, the last rostral segment has shown comparatively little variation in length, this is probably because in feeding; the aphid has to reach particular plant tissues, irrespective of its size. However, the length of the second joint of the hind tarsus does vary with the general size of the aphid, and can be varied under cultural conditions, so that there is considerable variation in the relative proportions of these appendages.

Relative Lengths of Longest Hairs on Antennal Segments III and Basal Diameter of the Segment.

As hair length has been used extensively by certain workers (Börner, (1921), Börner and Janisch (1922), Janisch (1926), Franssen (1927 and 1930)), more attention has been paid to this character, particularly since Börner (1940) described the short-haired *A. sambucina*. The above workers generally used the actual length of particular hairs as a systematic character, e.g. the hair nearest to the primary rhinarium on segment V and the marginal hairs on the abdomen, but Janisch also used the length of the antennal hairs in relation to the length of the segment bearing them. The writer has not used hair length for several reasons, e.g. it is often difficult to decide which hair to measure, they often lie at awkward angles in the mountant which makes for large errors in measurement, and it was thought that the length might vary for unknown reasons. It was argued that factors influencing the size of the hairs might also be expected to influence the size of the antenna, so that the comparison of the hair length with another antennal character would give a more reliable character. It was found convenient to use the diameter of the basal constriction of segment III as the second antennal measurement, the length of the longest hairs on III being used as the hair measurement; in practice, it is not always easy to measure the basal diameter of segment III. In the case of *A. sambuci* there is no clear evidence that the variation in these characters is closely correlated, as the thickness of the antenna is variable. However, the range of variation of hair length has been greater than the range in variation of the basal diameter of segment III; the hairs have varied from 4–16 units in length, and the base of segment III from 7–15 units in diameter, and the proportions have ranged from hairs $\frac{1}{2}$–2 times as long as the basal diameter of III. Some typical measurements are shown in Table I. For purposes of discussion it has been decided to call "long-haired" those apt. and al. v. ♀♀, in which the longest hairs are greater in length than the basal diameter of III, and "short-haired" those in which they are equal to or shorter.

All the root forms are short-haired, but under similar experimental conditions they did not all behave in the same way. The aphids on *S. nigra* roots were always short-haired, but became long-haired when transferred to the shoots; this also happened in nature. However, aphids from the roots of several of the secondary host plants remained short-haired after living for several generations on the aerial parts of *S. nigra*. On the other hand, all the spring forms found on *S. nigra* were long-haired, but under unfavourable experimental conditions became short-haired. In one experiment a clone was started using normal long-haired aphids; after three months the aphids were small and short-haired, but when transferred to a new plant the first generation consisted of long-haired aphids. Until the behaviour of the root forms was investigated it was thought that they were short-haired because of the difference in environment, and that when bred on *S. nigra* they would become long-haired. The reason for the persistence of short hairs in one set of aphids and not in another has not been discovered; a possible explanation may be that there is a genetical connection between short hairs and the tendency to migrate to secondary hosts, but if this is so, short-haired forms would be expected to occur on *S. nigra* in spring, so that this is a problem which needs to be investigated. The progeny of the crossing experiments have been examined for this character, the results being shown in Table V.

TABLE V.—*List of Crosses All of Which Gave Rise to Long-Haired Progeny.*

	Source and type of female.		Source and type of male.	
1.	*Dianthus*	S.H.	*S. nigra* clone	L.H.
2.	*S. nigra* clone	L.H.	*Dianthus*	S.H.
3.	*Dianthus*	S.H.	*Dianthus*	S.H.
4 & 5.	*S. nigra*	L.H.	*Saxifraga*	S.H.
6.	*Dianthus*	S.H.	*Saxifraga*	S.H.
7.	*L. dioica*	S.H.	*L. dioica*	S.H.
8.	*L. dioica*	S.H.	*S. nigra*	L.H.
9.	*L. dioica*	S.H.	*Dianthus*	S.H.
10.	*S. nigra* clone	L.H.	*S. nigra* clone	L.H.

L.H.—Long-haired.
S.H.—Short-haired.

From Table V it will be seen that irrespective of parentage the offspring were all long-haired, although, as mentioned above, there were slight morphological differences between several of the fundatrices.

These observations lead the writer to believe that *A. sambucina* is a synonym of *A. sambuci*, as it seems clear that long- and short-haired forms may exist side by side.

As far as the " Black Aphids " are concerned it is considered that before the subdivision of the group can be based upon hair length characters the sources and reasons for possible variation in the character must be thoroughly investigated.

Wax Adornment.

Abundant wax adornment seems to be a property of the typical spring forms—it appears to be lost under unfavourable conditions, and although healthy-looking aphids can be reared from unhealthy ones, the aphids do not seem fully to recover their powers of wax production. In the case of *A. sambuci* this character appears to be of little taxonomic value.

Secondary Rhinaria.

The variations which occur have been noted ; it seems to be possible that parallel variations may be found in spring forms of the "Black Aphids" in which it is well known that seasonal variations occur in the number of secondary rhinaria on antennal segments III, IV and V (e.g. Franssen (1930) and Janisch, (1926) indicate the differences between spring and autumn forms in several species).

The above variations in *A. sambuci* have been shown to occur in both clonal and randomly-collected material ; there is therefore no doubt that there is only a single species under consideration, and it is argued that it is necessary to prove whether or not a similar condition exists in the *A. fabae* complex. Jacob (1945 and 1947) has indicated some of the problems presented by the study of *A. fabae* ; as a result of this work on *A. sambuci* it is now suggested that some of them might very well be tackled by means of cross-fertilization experiments. This might be of particular value in cases where there are apparently wide differences in biology accompanied by only slight morphological variation, as in *A. fabae armata* Hausmann.

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THE INTERNAL MALE REPRODUCTIVE ORGANS IN THE GENUS *NABIS* LATREILLE (NABIDAE : HEMIPTERA—HETEROPTERA).

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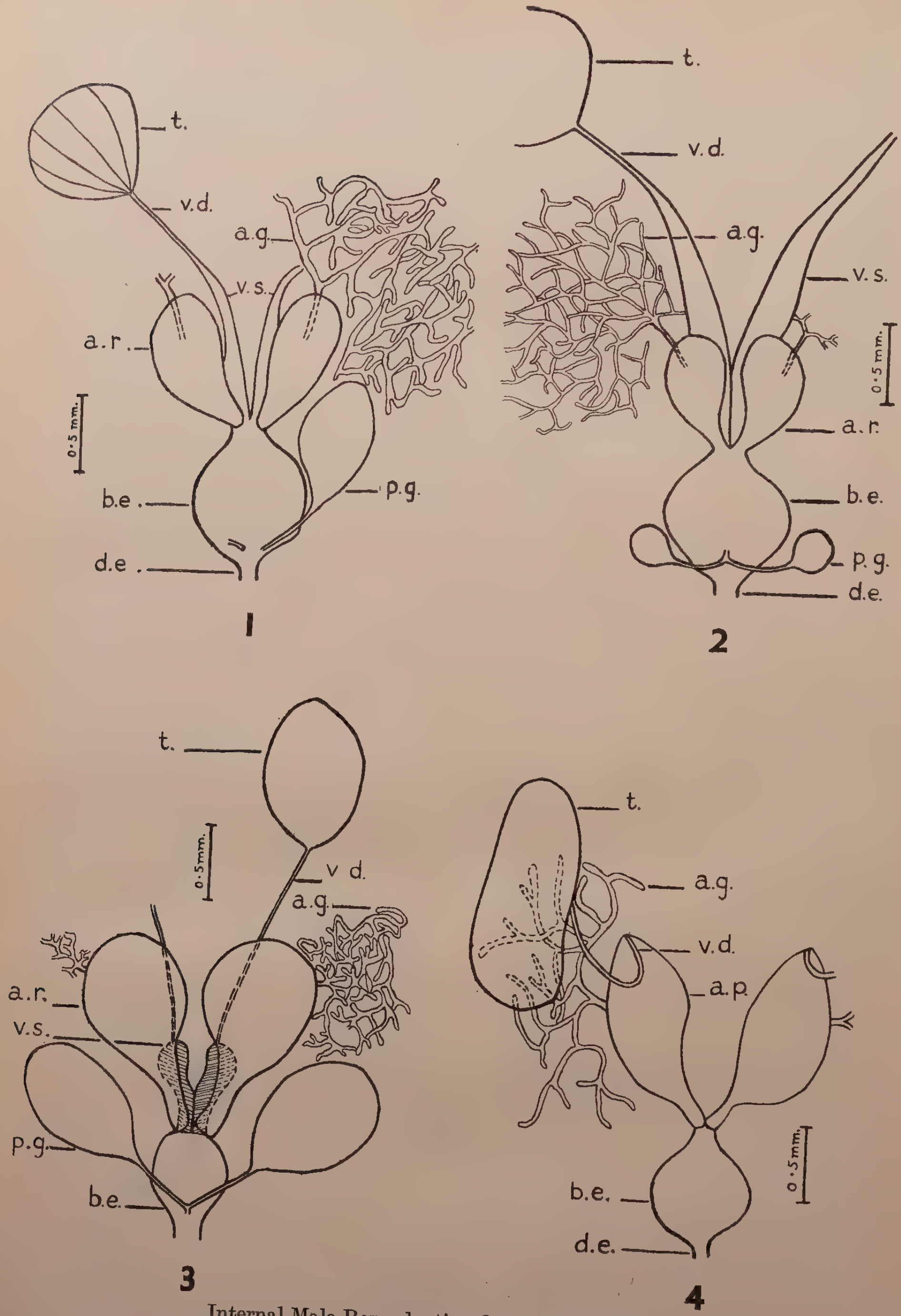
1. Comparative Structure.

The internal reproductive organs of the males of *Nabis* Latreille present a rather complicated structure which displays a certain amount of variation in the different species of the genus. So far as the English representatives have been studied, the different types of internal structure are seen to correspond to the several subgenera into which the group has been divided on the basis of external morphological features. In the following account China (1943) has been followed for nomenclature.

As an example of what appears to represent the most generalized type of structure, the male organs of *Nabis* (*Himacerus*) *major* (Costa) are first described. In this species (fig. 1) the testes are a pair of more or less pyriform bodies, from the posterior pointed end of each of which leads the narrow tube of the vas deferens. There are seven conical follicles in each testis, arranged in the form of a rosette, with their narrow bases meeting at the origin of the vas deferens. About halfway along its length the vas deferens gradually widens, its posterior dilated section functioning as a vesicular seminalis. The two regions are, however, not sharply demarcated, and the vesicula, though considerably wider than the vas deferens proper, is still of an elongate, tubular form. The two vesiculae seminales open close together into the anterior end of the bulbus ejaculatorius, a large, spheroidal, muscular sac formed by an anterior dilation of the ductus ejaculatorius, a slender tube which extends through the penis to the external male orifice. Into the anterior end of the bulbus also opens a pair of large sacs of elongate ovoid shape, one on each side of and somewhat dorsal to the base of the corresponding seminal vesicle, along the outer margin of which the sac is closely approximated. These two anterior reservoirs, owing to their constant association with large numbers of certain bacteria, as described in a later section, may be referred to as the "bacterial sacs." Into them open a pair of anterior glands (*mesadenes*). Each of these glands is an extensive, much-branched, tubular structure entering, by means of a single duct, into the ventral aspect of the bacterial sac at about a third of the distance from its anterior end. The white, ramifying tubules of the anterior glands lie freely in the posterior abdominal cavity around the reservoirs. Two posterior glands (*ectodenes*) open dorsally and posteriorly into the bulbus by a pair of slender ducts which terminate one on each side of the median line. The posterior, like the anterior glands, have a much-branched, tubular structure, but each is firmly invested by a sheath which gives a definite, sub-ovoid form to the whole gland.

In *N. lativentris* (Boheman) (fig. 2), a member of the same subgenus, *Himacerus* Wolff, the structure is essentially similar to that described in *N. major*, only minor differences distinguishing the two species. In *N. lativentris* the tubules of the anterior glands are finer than in *N. major*, and the two ducts of the posterior glands fuse at their proximal ends to form a very short common



Internal Male Reproductive Organs of *Nabis*.

Fig. 1–4 (1).—*N.* (*Himacerus*) *major* (Costa). (2).—*N.* (*Himacerus*) *lativentris* (Boheman). (3).—*N.* (*Nabis*) *rugosus* (Linn.). (4).—*N.* (*Dolichonabis*) *limbatus* (Dahlbom).

a.g., Anterior paired gland ; *a.p.*, anterior paired pouch (combined *v.s.* and *a.r.*) ; *a.r.*, anterior reservoir (" bacterial pouch ") ; *b.e.*, bulbus ejaculatorius ; *d.e.*, ductus ejaculatorius ; *p.g.*, posterior paired gland ; *t.*, testis ; *v.d.*, vas deferens ; *v.s.*, vesicula seminalis.

duct with a median opening into the bulbus ejaculatorius. In the specimens dissected, the posterior glands were much smaller than in *N. major*, but it is probable that the size of these glands is subject to seasonal or cyclical variation, such as has been observed in *N. ferus*. The structure of the male organs of the other British species of this subgenus, *N. apterus* (Fab.), has not yet been investigated.

The subgenus *Nabis* Latreille (fig. 3) is distinguished from *Himacerus* mainly by the much more complete differentiation of the vesiculae seminales. These are a pair of wide, thick-walled receptacles, very sharply demarcated from the vasa deferentia, which are extremely slender and thread-like throughout their whole length. The testes are sub-ovoid or pyriform, and the vasa deferentia leave them, as in the species of *Himacerus*, from their posterior ends. The posterior glands are similarly enclosed, each in a sheath of large ovoid form ; the two fine ducts unite at their proximal extremities immediately before entering the bulbus. The four species, *N. ferus* (L.), *N. rugosus* (L.), *N. ericetorum* Scholtz, and *N. flavomarginatus* Scholtz are similar in all points of structure, except that in the specimens of *N. flavomarginatus* dissected the vesiculæ seminales, although sharply demarcated from the vasa deferentia, were much narrower and more linear than in the other species. It is possible, however, that this may be accounted for by seasonal variation. The other British representative of the subgenus, *N. brevis* Scholtz, has not yet been studied, nor has *N. boops* Schiödte, the single and rather uncommon member of the subgenus *Stålia* Reuter.

It is in the subgenus *Dolichonabis* Reuter that the form of these structures appears to be most highly modified. In *N. limbatus* (Dahlbom) (fig. 4) the vesicula seminalis and the bacterial sac of each side have apparently fused to form a single large receptacle of roughly fusiform shape, opening into the anterior end of the bulbus ejaculatorius. Into this common sac lead both the vas deferens and the duct of the anterior gland, the former at its anterior apex, the latter somewhat ventrally at about a third of the distance from its anterior end. The testes are large and different in form from those of the other species described, being more or less kidney-shaped, with the attachment of the vas deferens in the "hilum" region, on what is topographically the inner side about half-way along its length. The follicles in this species are large, elongate, and cylindrical, rather than conical, as in other subgenera. The vasa deferentia are slender but rather short. The anterior glands are of the usual branched, tubular structure, with the tubules rather wide. There appear to be no posterior glands in this species. The one other species of *Dolichonabis*, *N. lineatus* (Dahlbom), has not yet been investigated.

Without developmental or histological studies, the anterior pouches in *N. limbatus* cannot be definitely homologized with the combined anterior reservoirs (bacterial sacs) and vesiculae seminales of the members of the other subgenera. There are, however, several features which indicate such an homology :

(1) The pouches receive both the vasa deferentia and the ducts of the anterior glands, and the topographical relations of these tubes are the same as with the vesiculae and the bacterial sacs respectively in those species in which these exist as separate organs.

(2) The anterior pouches of *N. limbatus* subserve the combined functions

of both organs, containing sperm as well as bacteria and the secretory products of the anterior glands.

(3) In all the species of *Nabis* investigated, the testis is ensheathed in a thin, tough membrane or "scrotum," which is of a conspicuous reddish colour ; in the subgenus *Nabis* bright red, in *Himacerus* orange, and in *N. limbatus* brick-red. In all species except those of the subgenus *Himacerus*, in which the vesiculae seminales are relatively undifferentiated, the walls of these latter organs are similarly coloured, but this pigmentation never extends to any of the other organs. Indeed, the line of junction between the vesiculae (of mesodermal origin) and the bulbus ejaculatorius (ectodermal) is very sharply demarcated by the difference in colour. In *N. limbatus* the walls of the anterior pouches are covered by a scattered reddish brown pigment, so that the general colour effect is by no means so intense as in the vesiculae of the other species dealt with above. The presence of reddish pigment in structures of similar position and size to those of the bacterial reservoirs of other species, in which it never occurs, certainly seems to indicate their fusion, in *N. limbatus*, with the vesiculae seminales. The diffusion of the pigment cells might then be explained by the merging of the walls of the two different organs.

The various types of structure of the male organs in the species of *Nabis*, so far as they have been investigated, accord with the taxonomic divisions of the genus and bear no relation to the nature of the reproductive cycle (e.g. length of adult life, whether the species hibernates as egg or adult).

The secretions of the two pairs of glands are quite different in appearance, and the possible functional significance of this difference is considered in a later section. The product of the anterior glands comprises a milky white fluid, including many small, spherical granules, whereas the posterior glands secrete an oily, yellowish or reddish brown liquid, with a pungent odour.

The differences in the structure of the various organs in the species of the three subgenera so far studied may be tabulated thus :

Subgenus.	Testes.	Vesiculae seminales.	Bacterial sacs.	Posterior glands.
Himacerus	Ovoid or pyriform. Vasa deferentia from posterior end.	Elongate, tubular. Not sharply demarcated from vasa deferentia.	Separate from vesiculae seminales.	Present.
Nabis	Ditto	Short, wide. Sharply demarcated from the slender vasa deferentia.	Ditto	Ditto.
Dolichonabis	Kidney-shaped. Vasa deferentia from middle of inner margin.	Apparently fused.		Absent.

2. Micro-organisms in the Reproductive System of *Nabis*.

In the anterior pouches of the males of all species of *Nabis* studied is found a closely packed mass of small, refractile, ovoid to rod-shaped cells of bacillus-like appearance, together with the small granules produced by the anterior glands. These bacteria are similar to those described by many workers as occurring in other species of Heteroptera ; they are Gram-positive and somewhat irregular in form and staining. Similar bodies were noted in large numbers in the testes and in some specimens in the bulbus ejaculatorius, and also in smaller numbers within the anterior and posterior glands and among the sperm in the vesiculae seminales. Those cells found in the testes appear to be all of the rod-shaped type. Such bacteria were observed in the bursa copulatrix and in the adjacent vaginal regions of some females, and in the mid-gut lumen of adults and of fifth instar nymphs, particularly in the region just anterior to the origin of the Malpighian tubes.

3. Discussion : Functions of the Anterior Glands and Reservoirs.

The constant occurrence of specific types of bacteria, usually regarded as symbiotic, in certain internal organs of insects, has been noted by many workers throughout a wide range of groups. Buchner (1930) and Steinhaus (1947) give a general review of this subject. In many species of Heteroptera, such bacteria are concentrated within a series of mid-gut caeca, which show a wide range of structure among the different members of the sub-order. Forbes (1882, 1896) and Kuskop (1923) described the association of bacteria with these caeca in certain Heteropteran species, and as early as 1857 Leydig had noted the presence of such micro-organisms in the caeca of a Pentatomid. Glasgow (1914) found such bacteria-filled caeca in members of the families Pentatomidae, Thyreocoridae, Pyrrhocoridae, Lygaeidae, and Coreidae, but in none of the entirely predaceous families of bugs. In Glasgow's opinion, " it seems not improbable that the present function of the caeca of the Heteroptera is merely to provide a safe place for the multiplication of the normal bacteria of these insects." The bacteria themselves, which are constantly present, and in an extremely wide range of forms specifically characteristic for the hosts, he considers, on the basis of experimental evidence, to function in excluding the foreign micro-organisms found in many of the related species that lack these caeca. The bacteria seem to be restricted to the alimentary canal of the bugs studied by Glasgow. He considers the transmission of the symbionts from one generation to the next as being through the egg, though not excluding reinfection from faeces by way of the mouth. The presence of the bacteria inside the eggs of Pentatomids is, however, refuted by Rosenkranz (1939), whose studies indicate that the symbionts are smeared over the surface of the eggs with the faeces of the female and are taken in by the proboscis of the newly hatched nymphs.

In the blood-sucking Triatomid, *Rhodnius prolixus* Stål., in which mid-gut caeca are absent, Wigglesworth (1936) has described a symbiotic Gram-positive bacillus (first noted in this species by Duncan (1926)) which occurs constantly in the cells and lumen of the mid-gut, and from preliminary experimental evidence suggests it provides a source of vitamin B, necessary for insect growth and reproduction. Wigglesworth found similar bacteria also in three other species of Triatomids, and Dias (1937) in nine species. In a later paper, Brecher and Wigglesworth (1944) have recorded that if *Rhodnius* is early deprived of its symbionts it rarely matures and probably never reproduces. They consider there is no constant mechanism of transmission, but that this is perhaps chiefly from infected excreta.

No observations of this nature appear to have been made hitherto in the allied family NABIDAE, all the members of which suck the body-fluids of insects. Mid-gut caeca are lacking also in this group, but, as has been indicated, bacilli were found in the posterior part of the mid-gut in the English species of *Nabis* investigated, and similar bacteria occur in very large numbers in the anterior pair of pouches of the male reproductive system, and also in the testes and male ducts and at times in the bursa copulatrix of the female. This heavy concentration of the bacilli in the male genital system (including the bulbus ejaculatorius) and their restriction to the posterior part of the reproductive system of the female, suggests that the method of transmission of these micro-organisms is probably from male to female by means of the seminal fluid, the testes having been invaded from the bacterial sacs, and the eggs being infected within the female at the time of fertilization. This supposition is strengthened by the existence in the male of the large pair of sacs with apparently the special function of storing these bacteria. In view of this function, it seems not improbable that the secretions of the extensive system of glands opening into the pouches serve to nourish the masses of bacteria during their retention in the male, a period which, particularly in those species which hibernate as imagos, must extend over a considerable length of time. The postulation of some such special function for these glands seems the more reasonable in view of the presence of the second (posterior) pair of glands which open directly into the bulbus ejaculatorius, through which the sperms must pass in the process of insemination. Their secretion is, moreover, of an obviously different nature from that of the anterior glands and presumably constitutes or at least contributes to the seminal fluid itself. A study of the development of the sacs and the life-cycle of the bacillus is desirable to elucidate the course of infection of the various organs of the host and the method of transmission of the bacterium. An interesting question arises in considering the male organs of *N.* (*Dolichonabis*) *limbatus*, in which the vesiculae seminales and the bacterial sacs are apparently fused, and the anterior glands open into the common pouches thus formed, the posterior glands found in members of the other subgenera being lacking. In this species, does the single pair of anterior glands subserve the functions of both of the two pairs of other groups ? A comparative histological study might prove illuminating here. It may be noted that the gland tubules in this species are wide in comparison with those of the anterior glands in members of the other subgenera.

The development of such special organs for the storage and apparently the nutrition of these bacteria strongly indicates an important function for these organisms in the physiology of the host, though whether this function is the same for the symbionts of *Nabis* as that put forward by Wigglesworth for those of *Rhodnius* could be determined only by experiment. Wigglesworth (1942 : 289) summarizes the evidence indicating the production by symbionts of a vitamin-like substance utilized by those insect hosts which subsist throughout life on a restricted and so presumably nutritionally deficient diet, such as plant-sap or blood.

In the males of the Pentatomid, *Nezara viridula* L., Malouf (1933) has described a pair of large pouches similar in morphological relationships and apparently in function to the anterior reservoirs of *Nabis*. There are, similarly, two pairs of branching tubular glands, though in this species neither pair opens into the pouches, one entering the mesodermal part of the ejaculatory duct and the other into the vasa deferentia. These pouches contain large numbers of rod-shaped bacteria embedded in a matrix which includes small, spherical granules. Similar bacteria infest the caeca of the mid-gut. Malouf considers that these micro-organisms are transmitted to the female with the sperm and so enter the eggs before they are laid. A mechanism of symbiont transmission similar to that suggested by Malouf for *Nezara* and in the present work for *Nabis*, has been described by Mansour (1934) in the Bostrychid beetle, *Rhizopertha dominica* F., in which the bacteria, having invaded the testis, are transferred to the bursa copulatrix of the female at pairing and here infest the egg. There are, however, in this species no special pouches on the male genital system for the storage of the micro-organisms. These are housed in a pair of spherical " bacterial cell-masses " with epithelial walls, one on each side of the alimentary canal near the anterior end of the proctodaeum, and, from these centres invade the testis lobes, which in the pupae are located close to the cell-masses.

In the males of *Agonoscelis versicolor* Fabricius, one of the PENTATOMINAE, Whitfield (1929) describes a pair of sacs which have similar morphological relations to those in *Nezara*, and during the present investigations similar sacs were found in another member of this sub-family, *Piezodorus lituratus* (Fabricius). Mid-gut caeca are present in both these species. In the male of the Cynid bug, *Sehirus bicolor* (L.), there is a more complicated series of one median pouch and two lateral pairs of sacs opening into the bulbus ejaculatorius. There are no mid-gut caeca in this species. None of these three above-mentioned species has been investigated for symbiotic bacteria.

In *Acanthosoma haemorrhoidale* (L.) belonging to the subfamily ACANTHOSOMINAE, generally regarded as one of the more primitive groups of the PENTATOMIDAE, there are mid-gut caeca, but no bacterial sacs in the male. In this species large numbers of rod-shaped bacteria are found in the mid-gut caeca. The absence of bacterial sacs in the male indicates that the transmission mechanism must be different from that occurring in *Nezara* and presumably in other Heteroptera with similar sacs. Indeed, Rosenkranz (1939) has described a special organ in the female with the function of smearing infected faeces upon the newly laid eggs.

4. SUMMARY.

(1) The different modifications of structure, which are described in the internal reproductive system of males in the genus *Nabis*, correspond, so far as they have been investigated, to the various subgenera which have been erected on the basis of external morphological characters.

(2) Opening into the bulbus ejaculatorius, in the males of all species of *Nabis* studied, is a pair of large pouches which serve to maintain a dense population of bacteria of similar type to those described in certain other species of insects, particularly among the Heteroptera, and generally regarded as symbiotic.

(3) Similar bacteria are found to invade other parts of the male genital system, including the testes, and may also occur in the bursa copulatrix of the female. In addition they infest the posterior portion of the mid-gut, which is devoid of caeca.

(4) It is suggested that the micro-organisms are transmitted to the female with the sperm during copulation and that infection of the eggs takes place at fertilization.

(5) Into each bacterial sac opens a large, much-branching, tubular gland, with a granular secretion very different from the oily secretions of a second, posterior pair of glands which open directly into the bulbus ejaculatorius. The anterior glands possibly supply nutritive material for the masses of bacteria stored in the associated sacs.

(6) Comparisons are made with other species of insects, particularly Heteroptera, in which similar structures, symbionts, and transmission mechanisms are involved.

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HUMBLE-BEE PARASITES AND COMMENSALS FOUND WITHIN A THIRTY MILE RADIUS OF LONDON.

By R. A. Cumber, Ph.D.

During 1946 and 1947 the study of humble-bees found in Buckinghamshire, Berkshire and Surrey has provided information on the parasites and commensals of these insects.

1. The Nematode *Sphaerularia bombi* Duf.

In Europe, accounts of the Nematode worm *S. bombi* have been written by Leuckart (1885*a*, 1885*b*), Sedgwick (1909) and Sladen (1912). This parasite has also been reported from America by Dimmock (1886) and Frison (1926).

During the spring and summer of 1946 the dissection of foraging queens of several species showed that many were parasitized by *S. bombi*. Towards the end of June over 80 per cent. of the foraging queens of *Bombus agrorum* (Fabr.) were found to be infected. At this stage, if the queen were enclosed in a tube, the parasites were soon found in large numbers on the glass.

During the spring of 1947 *Bombus* queens of different species were collected on Putney Heath, Surrey, from the time of their first appearance until their scarcity became marked. The dissection of these individuals has given the data which are summarized in Table I. The unbracketed figures are numbers of dissections, the bracketed figures the numbers of positive cases.

From this table it is seen that in the Putney Heath area the extent of parasitization is considerable, and that the degree of parasitization varies with the species, *Bombus lucorum* (L.) being particularly susceptible in this area.

Table I.—*Parasitization of "Spring" Queens by* S. bombi.

Species.	10.iv.47	11.iv	15.iv.	16.iv.	24.iv.	29.iv.	5.v.	6.v	7.v.	Totals.	% Parasitized.
B. lucorum	4 (3)	8 (5)	27 (14)	26 (15)	62 (48)	17 (15)	1 (–)	..	1 (–)	146 (100)	69
B. terrestris	4 (2)	2 (1)	8 (1)	8 (1)	5 (2)	..	2 (–)	2 (–)	..	31 (7)	23
B. pratorum	2 (2)	2 (–)	..	10 (2)	3 (1)	1 (–)	..	..	..	18 (5)	28
B. lapidarius	..	..	3 (–)	2 (–)	2 (1)	2 (–)	..	..	..	9 (1)	11
B. agrorum	..	..	2 (1)	4 (–)	..	3 (–)	..	1 (–)	2 (2)	12 (3)	25
B. hortorum	..	..	..	..	..	..	1 (–)	..	..	1 (–)	..
P. rupestris	..	..	..	..	1 (–)	..	..	..	..	1 (–)	..
P. barbutellus	..	..	..	1 (1)	..	..	..	..	..	1 (1)	..

The parasitic humble-bee, *Psithyrus* Lepeletier, is also shown to be subject to parasitization by *S. bombi*.

Until 29.iv.47 the queens were relatively abundant, but on and after this date the collecting was very difficult. This was mainly because the flowering of the species of *Salix*, which provide the earliest honey and pollen, had ceased, and the fruit trees in private gardens were now the main attraction. The bees found on the heath at this stage were unparasitized individuals which were looking for nesting sites.

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The gradual rise in the percentage of parasitized individuals of *B. lucorum* during April may be explained by the fact that the unparasitized individuals had already commenced to search for nesting sites, and thus were spending less time foraging. Queens with corbicular pollen and developed ovaries were first found on 24.iv.47.

The number of worms (reproductive females with outgrowths) found in a single queen varied from 1–68, and there was much variation in the stage of development of the worms from any one individual. Where large numbers were present there was a reduction in their average size, although some large worms always occurred. The worms were found in all parts of the abdominal cavity, but with a tendency to be ventral.

Effects of parasites on fat-bodies and ovaries.—Where parasitization is light (1–3 worms) the effect on the fat-bodies is not noticeable, but in heavier infections there is a marked reduction in their extent, and they become translucent or watery. In cases of severe parasitization many of the cells of the fat-bodies become clear and glassy, giving them a " beady " appearance.

The presence of a single worm will inhibit ovarial development. A succession of eggs does not develop, even though the ovaries may have the appearance of those of an unparasitized queen which has just come out of hibernation, i.e. a slight basal filling. More often, however—and this is particularly noticeable in severe parasitization—the ovarioles are reduced to translucent filaments, which are often separated by the bodies of the parasites.

The life-cycles.—The female parasite, which has presumably been fertilized in the free state, enters the abdominal cavity of the host during hibernation, gaining entrance through the intersegmental membranes. When the queens come out of hibernation in spring, some of the parasites have already begun to develop the curious outgrowth of the body-wall, which houses the generative organs. The eggs of the parasite, which, following the rupture of the generative organ, float freely in the abdominal cavity, were first recorded from a queen of *B. lucorum* on 24.iv.47, and the newly-hatched worms were first observed in an individual of the same species caught on 29.iv.47.

There seems little doubt that queens which are infected, and which, therefore, are unable to found colonies, seek out their old or similar hibernation sites, where they disseminate the parasites, thereby bringing about the infection of the new queens. The special nature of the hibernation site results in the moderate concentrations of hibernating queens which is necessary for the successful life of the parasite.

The wandering and searching of queens long after they would normally have established colonies has often been noted. Such searching is, however, noticeably slower and more clumsy than that shown by unparasitized queens in spring. During the second week of June, 1947, four of these late searching queens of *B. lucorum* were collected at Sunninghill, and dissection showed that all were parasitized.

2. AN UNDESCRIBED MITE FROM THE ABDOMINAL AIR-SACS. (TARSONEMIDAE).

During 1946 the dissection of humble-bees showed the presence of a mite living in the abdominal air-sacs of four species—*Bombus agrorum* (Fabr.), *Bombus ruderarius* (Müller), *Bombuprs atorum* (L.), and *Bombus terrestris* (L.), the infection of queen, male, and worker being recorded. In view of the fact that the "Isle of Wight disease" has a similar causative organism, and that such internal associations have been recorded only in the American locusts *Hippiscus* and *Arphia* (Wehrle and Welch, 1925) and the honey-bee, this occurrence is of some interest.

Life-cycle.—Female mites present in the abdominal air-sacs of overwintering queens are observed to be gravid when the queens come out of hibernation in spring. About 3-4 weeks later the mite commences egg-laying, and the eggs come to lie about her, giving the infection a very characteristic appearance. The presence of the parasites does not hamper the queen to the extent that she is unable to establish a colony successfully. By the time that she has produced a number of workers, the eggs of the mites (there are usually several females in a queen) have hatched. It is probable that the workers become infected in much the same manner as occurs in the spread of *Acarapis woodi* Rennie, in *Apis*. The females of the new brood of mites, having been fertilized either within the abdominal air-sacs or on the external surface of the queen, pass by contact to the other individuals of the nest, gaining access to the air-sacs through the abdominal spiracles. Here the mite absorbs nutrition from the coelomic cavity of the host by pushing its proboscis through the wall of the air-sac. It soon becomes gravid and repeats the cycle shown in the queen. The mites produced here infect other workers, and subsequently the male and queen humble-bees which are produced later in the season.

Two infected nests of *B. agrorum* showed 50 per cent. and 92 per cent. positive cases amongst workers, and 100 per cent. infection of new queens.

Specimens of this mite have been seen by Mrs. Hughes, of the London (Royal Free Hospital) School of Medicine for Women, who has indicated that they are possibly a species of *Tarsonemus*.

3. CONOPIDAE (Diptera).

According to Sladen (1912) and Friese (1923), the larvae of European Conopid flies may parasitize humble-bee broods. No evidence of this has been found, however, and information is in accordance with that of Frison (1926) and Plath (1934).

During 1946 the dissection of worker humble-bees from both random foragers and from nests has provided some data on parasitization by Conopid flies.

Data from foraging workers is summarized in Table II, that from nests in Table III. Table IV gives data on the numbers of Conopid pupae found in nests during 1947.

In the data from nests, where all the workers were not dissected, a representative sample of those taken with the nest and those taken returning to the site was dissected. In the nest of *B. agrorum*, taken on 6.viii.46, 24 workers taken with the nest showed no infection, whereas 20 workers returning to the site yielded 5 larvae. This provides evidence of a foraging caste. It is strange that two adjacent nests of about the same strength and taken at approximately the same time showed no parasitization.

Life-cycle.—Adult Conopid flies may be found on and in the vicinity of flowering plants early in June. From this position they have been observed to attack workers of *B. agrorum*, and presumably they lay the egg within the abdomen of the bee while momentarily clasping it in mid-air.

TABLE II.—*Parasitization of Foraging Workers by Conopid Flies* (1946).

Species.	Number of specimens dissected.	Positive cases.	Date range of dissections.	Date range of positive cases.
B. agrorum	81	13*	1.vii–30.viii	29.vii–30.viii
B. hortorum	31	4	1.vii–12.viii	17.vii–29.vii
B. lapidarius	38	4	1.vii–21.viii	29.vii–21.viii
B. ruderarius	12	1	17.vii–12.viii	29.vii
B. terrestris	17	1	1.vii–29.vii	29.vii
B. pratorum	13	–	1.vii–17.vii	..
B. humilis	1	–	12.viii	..
B. sylvarum	1	–	12.viii	..

* Includes 1 male.

TABLE III.—*Parasitization of Workers from Nests by Conopid Flies.*

Species.	Date.	Number of ☿☿ in nest.	Number of ☿☿ dissected.	Positive cases.
B. agrorum	8.vii.46	28	28	–
B. hortorum	15.vii	28	28	–
B. lapidarius	19.vii	99	24	–
B. agrorum	24.vii	11	11	–
B. ruderarius	26.vii	9	9	2
B. agrorum	6.viii	111	44	5
B. lapidarius	12.viii	7	7	1
B. agrorum	13.viii	62	24	–
,,	15.viii	81	24	–
,,	19.viii	28	28	–
,,	25.viii	12	12	1

TABLE IV.—*Conopid Pupae Found in Nests.*

Species.	Date.	Number of pupae.
B. agrorum	8.ix.47	4
B. ruderarius	8.ix.47	19
B. humilis	8.ix.47	2
B. agrorum	9.ix.47	6, 2
B. sylvarum	9.ix.47	1

TABLE V.—*Emergence of* P. rufipes.

Date.	Number emerged.	
	Females.	Males.
31.v–1.vi	1	5
2.vi–4.vi	2	3
5.vi–6.vi	1	4
7.vi–8.vi	1	..
9.vi–10.vi	1	..

The larva in its earliest stages is free, but soon it attaches itself to a trachea or air-sac by its posterior pair of spiracles. There is a tendency for a large larva to attach itself to one of the lateral trunks, and thus to lie at right angles to the long axis of the abdomen. In no instance was an individual found to contain more than one larva, although Severin (1937) records two larvae of *Zodion fulvifrons* Say from workers of *Apis*. The fat-bodies of the host become pale in the presence of the parasites.

Workers are able to forage until larvae are quite large, when either the bee falls by the wayside, or returning to the nest, dies within. The larva finishes what little food there remains, and usually pupates *in situ* with its posterior spiracles to the posterior end of the abdomen. The dead bee is removed to the entrance or placed in an out-of-the-way position by the workers, where it remains till the emergence of the adult parasite in the following summer. By this time the abdomen has usually become separated from the rest of the bee, and the adult emerges by pushing aside the anterior segments with its ptilinum.

It is easy to distinguish those dead workers which contain larvae or pupae because the presence of the latter prevents the shrinking of the abdomen, which remains distended and rigid, and not contracted as in the normal dead bee.

During the first week of September, 1946, 22 parasitized abdomens taken from a nest of *B. agrorum* were placed in damp earth, and kept in a shed during the winter. Table V shows the record of their emergence in 1947. The adults were identified as *Physocephala rufipes* (Fabr.).

4. *Brachycoma devia* (Fallén), Diptera, TACHINIDAE.

Short accounts of parasitization of humble-bees by Tachinid flies of the genus *Brachycoma* have been given by Sladen (1912), Frison (1926) and Plath (1934).

In England most nests of *Bombus* are parasitized to some extent by the Tachinid fly *B. devia*. It has been found in nests of the following species—*agrorum*, *hortorum*, *humilis*, *ruderarius*, *sylvarum*, *lapidarius*, *lucorum*, *pratorum*, and *terrestris*.

Life-cycle.—The adult flies appear early in May. The females, which are larviparous, enter the nests of *Bombus*, where they commence to lay. Whether or not these larvae are laid at the same time as the host is ovipositing is not known, but the larvae are found wandering over the eggs and all succeeding stages up to the early pupal stage. While the larvae of *Bombus* are growing, the Tachinid larvae show no noticeable increase in size. When, however, the bee larva ceases to feed, and having spun a cocoon passes into the prepupal stage, then it is savagely attacked by the Tachinid larvae, of which as many as 24 have been found in a single cocoon. The larvae puncture the surface of the prepupae, particularly on the sides and ventral surface, causing a black mottling of the cuticle. Usually the number of larvae per cocoon is from 1–4, and these grow very rapidly. When they have finished feeding the Tachinid larvae force their way out of the cocoons, which have become softened by the foul-smelling by-products, leaving a small round hole, which is usually basal and at one side. The larvae then make their way into the substance of the nest material, on which they pupate. 64 of these empty puparia were taken from a nest of *B. hortorum* on 15.vii.46. The pupal stage of these earlier larvae lasts about two weeks.

The larvae produced later in the season, however, tend to leave the nest material and pupate in the soil nearby, where they may be found after the nest has died out. These are the over-wintering generation. The puparia are noticeably darker than those produced early in the season.

It seems certain that *B. devia*, if not responsible for the early termination of many nests, is responsible for a very heavy toll amongst the humble-bee populations. In some nests over 200 puparia and larvae have been found, and in a nest of *B. terrestris* taken on 31.vii.47 there were over 100 cocoons in which the brood had been destroyed by this parasite.

Those nests situated near the surface and with exposed entrances appear to suffer more heavily, but nests with even the most tortuous tunnels always appear to have some degree of parasitization.

5. *Volucella bombylans* (L.), Diptera, SYRPHIDAE.

Towards the end of the season the larvae of the Syrphid fly *V. bombylans* are often found in the material beneath the nests, particularly of the "carder-bees." They have been found in nests of *B. ruderarius*, *B. humilis*, *B. sylvarum* and *B. agrorum*, as many as 30 being found in the one nest.

No harm is thought to result from the presence of these larvae, which appear always to remain well below the brood while the nest is at all populous. Only when it has almost died out do they invade the upper portions of the nest. During their growth they favour a dry medium, and in wet weather tend to group about the last remaining dry centres in the nest.

An attempt to overwinter the larvae in earth proved unsuccessful. A visit to a site (1946) of a nest of *B. agrorum* on 10.v.47 yielded a single larva of *Volucella*. This was found amongst the leaf bases above the nest and was quite active at this stage. It was kept in a 3 in. by 1 in. glass tube with a gauze cap. Damp grass blades were added from time to time.

The larva rounded up during the week-end 6–9.vi.47. The adult, a female of the white-tailed form, emerged during the week-end 27–30.vi.47.

6. *Fannia* spp., Diptera, MUSCIDAE.

The larvae of *Fannia* are found in nests of *Bombus*, particularly when they are in the process of dying out. Like the larvae of *V. bombylans*, they appear to be scavengers with no direct effect on the life of the colony. Hundreds have been found in nests of certain species which nest on or near the surface. The larvae have been found in nests of *B. agrorum*, *B. hortorum*, *B. ruderarius* and *B. pratorum*.

7. *Aphomia sociella* (L.), Lepidoptera, GALLERIIDAE.

Although over 120 surface nests have been studied in Buckinghamshire and Berkshire during 1946–47, only one was found to be parasitized by the Humble-bee Wax-moth *A. sociella*. This was a nest of *B. ruderarius* from Slough, which was almost completely destroyed at its climax. The nest was opened on 17.vii.47, when it was found that the larvae of the moth had spun a considerable amount of the nest material into a solid wad of cocoons.

8. COLEOPTERA.

The following are records of Coleoptera found in nests of humble-bees during 1946 and 1947 :

B. agrorum : *Epuraea depressa* Gyllenhall. NITIDULINAE.
Antherophagus nigricornis F. MYCETOPHAGINAE.
Cryptophagus setulosus Sturm. CRYPTOPHAGINAE.
B. ruderarius : *E. depressa, A. nigricornis, C. setulosus.*
B. hortorum : *E. depressa, A. nigricornis.*
B. pratorum : *E. depressa, A. nigricornis, C. setulosus.*
B. terrestris : *A. nigricornis, C. setulosus.*
Leptinus testaceus Muller. LEPTINIDAE.
Ptomophagus varicornis Rosenhaver. CHOLEVIDAE.
Ptomophagus subvillosus Goeze. CHOLEVIDAE.
B. lapidarius : *E. depressa, A. nigricornis.*
B. lucorum : *A. nigricornis.*

9. PARASITE OF UNKNOWN TAXONOMIC POSITION. (? Hymenoptera.)

In 1937 Legge published an account of what were apparently hymenopterous parasites from the abdominal cavity of a queen of *B. terrestris* captured at Slough. During June, 1946, two more records of what is apparently the same parasite were obtained from the same district. One, a queen of *B. agrorum*, contained 20 larvae (3–5 mm.), and in a worker of the same species 8 (2–3 mm.) larvae were found.

Plath (1934) has also described and figured the larvae and coccoons of an unrecorded hymenopterous parasite of queen humble-bees.

In the specimens taken at Slough (1946) there is a development of white spherical lumps apparently associated with these parasitic larvae. The largest of these are approximately 1 mm. in diameter, and a range exists to those which are just visible under the high power of the binocular. They are very numerous, especially on the external aspect of the fat-bodies, and some, no doubt set free by the wandering larvae, are found lying in the fluid of the abdominal cavity. That these bodies are associated in some way with the presence of this larva seems probable, since they were present both in the queen and worker referred to above, while the dissection of some considerable numbers of unaffected queens and workers during the same month failed to disclose their presence. Similar bodies were observed in the gut of larvae from both the queen and the worker.

10. The PARASITIC HUMBLE-BEE, *Psithyrus*.

Data from nests.—Five nests have provided some data on the parasitic humble-bee, *Psithyrus.*

B. hortorum, 28.vi.46, Slough.—The nest contained 10 ☿☿, 1 ♂ of *B. hortorum* and a queen of *P. barbutellus.* The nest was severely attacked by *Brachycoma devia.* The parasitic queen was covered with a sticky substance, which matted down her pile. The brood consisted of 9 eggs, 55 larvae and 3 prepupae. All the workers had well developed ovaries.

B. lapidarius, 19.vii.46, Slough.—A dead queen of *P. rupestris* was found in the nest material. The nest contained 99 ☿☿ of *B. lapidarius* and 7 ♂♂ of *P. rupestris.* Brood consisted of 12 unemerged callows, 152 pupae (all males), 20 prepupae, a large number of larvae belonging to all instars, and egg groups 10/12/10/14/39/25. Workers were laying. There were no queen cocoons, nor were any of the larvae large enough to be queen larvae.

B. lapidarius, 12.viii.46, Slough.—This nest contained 7 ☿☿, and one group of 12 small yellowish cocoons. Some old comb present gave no indication of queen brood having been produced. A dead queen of *P. rupestris* was found. The cocoons contained prepupae, one of which was successfully incubated and produced a male of *P. rupestris*.

B. lucorum, 16.vi.47, Sunninghill.—This nest contained 30 ☿☿, 1 queen of *B. lucorum* and 1 queen of *P. bohemicus*. Both queens were laying, but no workers showed any noticeable ovarial development. Brood consisted of 3 unemerged callows of *Bombus*, 50 pupae, 10 4th instar, 6 3rd instar and 3 2nd instar larvae. There were 45 *Bombus* eggs and 62 *Psithyrus* eggs, and the distinction between these was quite marked, the eggs of the latter being more slender and slightly longer. This nest represents the stage of increasing dominance of the parasitic queen.

B. agrorum, 5.x.47, Slough.—This nest had almost died out. The comb showed that queens had been produced in small numbers. A few workers of *B. agrorum* were present, together with two young queens of *P. campestris*.

OVARIOLE NUMBER.

The number of ovarioles in *Bombus* is invariably 4.4. In *Psithyrus*, however, in keeping with parasites of this type, there is a considerable increase in the number of ovarioles, and the number is not constant. In *Bombus* the active ovariole is much longer than that of *Psithyrus*. Table VI gives records of ovariole numbers found during dissections made in 1946 and 1947.

According to Sladen (1912), the *Psithyrus* queen locates the nest of the host species while this is in an early stage of development, and lives there as a guest until her ovaries have developed. By this time the nest contains a moderate number of workers, which are necessary if the parasitic queen is to be successful.

TABLE VI.—*Number of Ovarioles in* Psithyrus.

Species.	Date.	Ovarioles per ovary.
P. barbutellus (Kirby)	28.vi .46	10.10
,,	10.vii.46	10.12
,,	16.iv .47	6.7
,,	16.iv .47	8.9
P. bohemicus (Seidl.)	17.vi .46	14.13
P. campestris (Panzer)	10.vii.46	7.8
,,	17.vii.46	6.7
P. rupestris (Fabr.)	24.vi .46	18.15
,,	24.vi .46	15.13
,,	1.vii.46	16.14
,,	9.vii.46	15.13
,,	29.iv .47*	12.14
P. vestalis (Geoffroy)	27. v .46	10.10

* This queen was not fertilized, and it would be interesting to learn what percentage of *Psithyrus* queens found in the spring are not fertilized.

The development of the ovaries of the *Psithyrus* queen is dependent upon the amount of food which she can obtain, and her change from guest to parasite takes place only when a certain degree of prosperity has been reached in the nest.

Plath (1934), however, records cases where parasitic queens have taken over quite populous nests, and have commenced laying in these on the same day.

It is suggested that the taking over by the *Psithyrus* queen results in a sudden fall in the brood/worker ratio. Consequently no workers of *Psithyrus* are produced, although a considerable variation in size amongst female individuals of the same species has been recorded.

Hoffer (1882), Frison (1916) and Plath (1934) have found that in many nests the *Psithyrus* and *Bombus* queens live together, but that under such conditions *Bombus* eggs are not allowed to develop. The nest of *B. lucorum* described above shows that the egg-chambers of both queens may occur at the same time.

It is not possible to lay down any hard and fast rules concerning many of the relations between *Bombus* and *Psithyrus*, for the plasticity of habit shown by the former also manifests itself in the biology of its parasite. It would appear that in the past too much emphasis has been laid upon behaviour of species and host, and not enough upon conditions under which such behaviour occurs. In nests of a similar state of economy, it may well be that the attitude of parasite to host follows one type of behaviour, independent even of the species concerned.

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SEASONAL RECORDS IN 1947 AND 1948 OF FLYING HEMIPTERA-HETEROPTERA, PARTICULARLY *LYGUS PRATENSIS* L., CAUGHT IN NETS 50 FT. TO 3,000 FT. ABOVE THE GROUND.

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In 1947 and 1948, nets up to a height of 4000 ft. above the ground were used to study the movement of aphids. During these operations many other insects were caught; but of these only the Hemiptera-Heteroptera have, so far, been identified, and we publish these records for the significance they may have for Hemipterists on the problems associated with the dispersal of these insects.

The results given here have not been analysed in relation to meteorological factors, for the records of two seasons provide insufficient data. No consideration can therefore be given at present to the reasons why insects were at higher levels on some days than on others; this aspect is part of a wider study now being made in this department.

Trapping at 50, 250, 500, 1000, 1500, 2000, 3000 and 4000 ft. Above Ground Level.

This trapping was all done at Cardington, near Bedford, with the kind co-operation of the staff of the Research and Developmental Establishment, Ministry of Supply. A barrage balloon was flown at a little over 2000 ft. or 4000 ft. and 6 nets each 3 ft. in diameter and made of fine voile were attached to the balloon cable at different heights so as to fly simultaneously. The ground from which the balloon was flown was a grass sports field, and the immediate neighbourhood consisted mainly of farm land and allotments. Suitable devices kept the nets closed on the upward and downward journey to and from the operational heights at which the nets were opened and actual trapping took place. From 23rd June to 19th August nets were flown simultaneously at 50, 250, 500, 1000, 1500 and 2000 ft., and from 20th August onwards at 50, 250, 1000, 2000, 3000 and 4000 ft. Occasionally a net failed to open, but this was so infrequent as to be of no significance to the results recorded here. It was usual to start operations at about 9 a.m. (B.S.T. or D.B.S.T.). No trapping took place after dark.

Details of all these methods will be published in due course.

Records of the Catch.

The number of Heteroptera caught is a very small proportion of the total catch. At all heights at Cardington from 23rd June to 31st October, 1947, a total of 35,447 insects were caught; of these 21,334 were aphids and only 37 were Heteroptera (Table I).

Records of the Heteroptera in 1947 are as follows :

Piesma maculata Castelnau, 50 ft., 11.xi (1) ; 250 ft., 1.viii (1) ; total 2.
Nabis ferus L., 50 ft., 12.viii (1) ; total 1.
Acompocoris pygmaeus Fallén, 250 ft., 27.viii (1) ; total 1. (Not recorded for Bedfordshire in Bedwell, 1945.)
Xylocoris gelactinus Fieber, 50 ft., 6.viii (1) ; 2000 ft., 19.viii (1) ; total 2.
Orius majusculus Reuter, 50 ft., 19.viii (1) ; 2000 ft., 19.ix (1) ; total 2.
Anthocoris spp. (unidentifiable), 50 ft., 14.viii (1) ; 19.viii (1) ; total 2.
Anthocoris nemorum L., 50 ft., 14.viii (1) ; 22.viii (1) ; total 2.
Lygus pratensis L., 50 ft., 22.viii (1) ; 28.viii (1) ; 2.x (1) ; 250 ft., 2.x (5) ; 3.x (3) ; 6.x (1) ; 20.x (1) ; 1000 ft., 24.ix (1) ; 2.x (2) ; 3.x (1) ; 6.x (1) ; 2000 ft., 1.ix (1) ; 6.x (1) ; 3000 ft., 16.ix (1) ; total 21.
Lygus kalmii L., 50 ft., 27.viii (2) ; 500 ft., 8.viii (1) ; total 3.
Liocoris tripustulatus Fabricius, 50 ft., 22.viii (1) ; total 1.

TABLE I. *Number of Hemiptera-Heteroptera, Aphids and Other Insects taken at Different Altitudes at Cardington*, 1947.

Altitude (ft.) above ground.	Flying hours.	Hem.-Het.	Aphids.	Other insects.
50	532	15	9,042	7,449
250	513	12	4,884	2,395
500	292	1	2,857	1,311
1000	528	5	2,212	1,176
1500	284	0	1,687	623
2000	496	3	614	1,054
3000	231	1	25	40
4000	222	0	13	65
	Totals	37	21,334	14,113

The species of Heteroptera most in evidence in 1947 was *Lygus pratensis* L. This insect was most commonly caught in the late summer and in the autumn, a fact probably associated with its migration from wild to cultivated plants in the late summer and also with a probable increase in its populations at that time when the second generation of adults appears (Fox-Wilson, 1938).

Now *L. pratensis* is very common in Britain, but its numbers in 1947 were unlikely to be so large as to outweigh those of all the other capsid species of about the same size and weight. It is curious, therefore, to find it captured, especially at considerable heights, in numbers which far exceed those of other capsid species. One is led to suppose that *L. pratensis* possesses some peculiarity of habit (e.g. of climbing to the tips of leaves, or a periodicity of flight which coincides with a time of maximum upward convection) which makes it particularly liable to attain great heights. The only capsids caught at Cardington in 1947 were, in fact, 21 *L. pratensis*, 3 *L. kalmii*, and 1 *Liocoris tripustulatus.*

A similar predominance of *Lygus pratensis* in the air at high altitudes has been recorded in the U.S.A. by Glick (1939) who captured it at heights up to

5000 ft.; and Coad (1931) specifically mentions its capture at 3000 ft. There is, however, some doubt cast upon the correct identification of this species in the U.S.A. by Knight (1942), who points out that many American records of *pratensis* should, in fact, be to *Lygus oblineatus* Say.

L. pratensis was the commonest capsid taken in the Rothamsted light trap ($4\frac{1}{2}$ ft. above ground) from 1933–1936. Only 3 other species, *Adelphocoris lineolatus* Goeze, *Asciodema obsolutum* Fieber and *Megalocoleus molliculus* Fallén approached it in commonness (Thomas, 1938).

The results for 1948 at Cardington were exceedingly disappointing, and only 5 individual Heteroptera were captured, although nets were flown regularly from May to November, and nearly 12,000 aphids were caught over that period.

The records of Heteroptera for 1948 were as follows:

Drymus sylvaticus Fabricius, 50 ft., 24.viii (1); 500 ft., 27.viii (1); total 2.
ANTHOCORIDAE. Species unidentifiable. 50 ft., 30.vii (1); total 1.
CAPSIDAE. Species unidentifiable. 250 ft., 24.viii (1); total 1.
Lygus pratensis L., 50 ft., 2.xi (1); total 1.

No Heteropteron was captured at 4000 or 1500 ft. in 1947 nor at 1000, 1500 or 2000 ft. in 1948.

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The Society is prepared to undertake the provision of a reasonable number of text figures. The original drawings for such figures must be supplied by authors. Such drawings or groups of drawings must be drawn to a scale which will permit of their reduction to an area of dimensions not exceeding 7½ by 4½ in. In the case of the *Proceedings Series A* and *Series B*, authors may be required to pay for the necessary blocks for the provision of plates, half-tone and coloured work.

A uniform method is adopted for the citation of bibliographical references in the Society's publication as follows :

Smith, A., 1936, New Species of COCCIDAE. *Proc. R. ent. Soc. Lond.* (B) **6** : 301-306, pl. 1.

——, 1936, New species of COCCIDAE. *Trans. R. ent. Soc. Lond.* **84** : 901-936.

Titles of periodicals cited are to be abbreviated in the manner indicated in the *World List of Scientific Periodicals, 2nd edition*, 1934.

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MEETINGS

TO BE HELD IN THE SOCIETY'S ROOMS

41, Queen's Gate, S.W. 7

1950

Wednesday, January 18 (Annual Meeting)
" February 1
" March 1
" April 5
" May 3
" June 7

THE ROYAL ENTOMOLOGICAL SOCIETY OF LONDON

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